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ARTICLES

THE FARMER'S ATTITUDE TO NEW METHODS

Paper read by Professor Robert Rae, Director of the National Agricultural Advisory Service, to the joint meeting of Section J, Psychology, and Section M, Agriculture, of the British Association for the Advancement of Science, Belfast, September 1952.

Before going into any details, I suggest it would be unwise and unfair to generalize—farmers, of whom there are some 370,000, form a cross-section of human beings like any other group, with a top, a tail and a middle which stretches upwards and downwards. Perhaps it varies from most other large groups in that it is composed of a large number of small units each operating on its own with varying but definite isolation from its neighbours, who are not down the street but over the hill, across the river or up the next lane on the right. Although we have some very large farm units, the United Kingdom is in the main a country of medium to small farms. The pattern is as follows :

Number and Percentage Distribution of Holdings* in England and Wales and Great Britain by Acreage Size Groups June 1950

	1-5	5-15	15-30	30-50	50-100	100-150	150-300	Above 300	Total
England and Wales 1950	77,022	72,496	45,139	40,846	59,950	31,088	33,619	12,614	372,774
% of whole	20.4	19.5	12.1	11.0	16.1	8.4	9.0	3.5	100
Great Britain 1950	94,434	90,975	53,241	47,213	69,939	36,899	40,087	14,778	447,566
% of whole	21.1	20.3	11.9	10.5	15.6	8.3	9.0	3.3	100

*The statistics for England and Wales and for Great Britain relate to the acreage of crops and grass, excluding any acreage of rough grazings. Holdings consisting solely of rough grazings are excluded.

It must also be realized that one of the significant features of British farming is the great diversity of agricultural conditions which affect the type of farming. Altitude rises from the broad acres of low land in the east to the highlands of the west. Rainfall varies in the same direction from 20 to 25 inches in the east to 100 inches or more in the western hills. Soils have a profound influence not only on the system of farming but also on the particular crops grown. All I want to emphasize here is that they are so diverse that no general brief description is possible—we have an extraordinary mixture of alluvia, sands, gravels, loams, clays, the low ranges of chalks (downs) and limestone

(the wolds) and, travelling west again, the older formations derived from sandstone and still older granites. The changes in soil type may occur within a very narrow area, sometimes on the one farm. The combination of these geophysical factors means that changes or developments which may be suitable and profitable for one area may not be applicable to another, or may even be definitely wrong. Further, with a climate like ours which at will produces long dry summers or equally long wet summers, results from a new technique, variety of crop or other change obtained in one season may not be repeated the following; they may even be reversed. Some degree of caution is therefore well justified before adopting some new idea or method proved successful elsewhere until it has been tried out under conditions comparable with the individual farm or district. The recognition of this fact is one of the main reasons underlying the setting up in England and Wales of a chain of Experimental Husbandry Farms. The location of these farms is based on geophysical conditions, and when the number is completed it is hoped they will cover the main soil, site and rainfall combinations.

It may not be inappropriate, before I go into details or become critical, to refer briefly to the notable achievements of British farmers of past generations. Prior to the middle of the eighteenth century, Flanders and the Low Countries led in the field of agricultural development, and to them we owe the introduction of many of our crops and much of the blood which went to improve our rather scrubby cattle herds of those days. From that time, however, and for a hundred years and more it is difficult to find agricultural improvements which were not British: Tull and his husbandry of growing crops in straight rows, the first drill and horse-hoe; Meikle, the first thresher that really worked; Bell and his reaper; Reade and his drain tiles; Fowler, who first ploughed and cultivated by steam; and, on the livestock side, Bakewell, Booth, Bates, Cruikshanks, Tulley, etc., who founded many of our present-day breeds on which the livestock industry of this and many other countries is based. True, these men were the outstanding pioneers, but the development of their innovations had to be carried on by a host of enterprising ordinary farmers.

It should be remembered that agricultural science is very new. It is barely a century since it reached the stage of being able to point to better methods. We should also remember that the scientist has often been wrong. By contrast, farming tradition is very old—going back perhaps seven thousand years. Modern methods of production are based partly on scientific discovery and partly on age-old experience. In considering the case for a change, the farmer must balance the evidence of science against that of tradition, and attempt a reconciliation of the two. It is commonly said that farmers, on the whole, rely too much on tradition and too little on science. But that is too sweeping a generalization. If we want to assure ourselves of the value of traditional knowledge, we have only to look at the disastrous results of

having to do without—e.g., the deplorable amount of soil erosion that has occurred in the new countries. But, admittedly, tradition can outlast its usefulness. It was once true that " to make a pasture will break a man ". It was once right and proper that a landlord should exact a heavy penalty for the breaking up of permanent grass. In advising a farmer to plough out and reseed a field of old pasture, or a landowner to waive the penalty against this, we have to show that what was once true and proper is so no longer. We must point to the new knowledge and new resources that are available and prove that past experience is no longer a good guide.

Adoption of Improved Practice

In discussing some of the factors which may influence the farmer's attitude towards the adoption or otherwise of some technical advance into his own farming system, no attempt is made to put these in any order of significance. I would question the feasibility of doing so. Nevertheless, I would personally put high up the general economic level of farming; that is, whether there is or is not, over a period of years, the prospect of a reasonable profit from the business of farming. The need for greatly increased production from home agriculture during the war years gave rise to increased prices. That need continued into the post-war years, due to the nation's economic position, and, incidentally, it would appear to continue as far ahead as one can see. The Agriculture Act of 1947 provides, on the one hand, a guaranteed market at prices fixed annually for the major farm products (there is a qualification in the Act as to quantities) ; gives greater security of tenure to tenant farmers ; and, on the other, requires a reasonable standard of efficiency with legal sanctions against those who persistently fall below and remain at the tail end. While any system of price fixing always leaves room for individual views, it can with fairness be claimed that, as contrasted with pre-war conditions, today's system should be more conducive to planning ahead and willingness to try new ideas or methods. The conditions that prevailed through the inter-war period of the 'twenties and early 'thirties were difficult and uncertain, and for many farmers it was a hard struggle to keep their heads above water ; in fact, many went under. When the price to be obtained for a crop is unknown at sowing date, and the ultimate value of fat animals, which take one, two or three years to produce, is subject to wide variation, and when the prices eventually realized do not cover costs of production, there is not much encouragement to progress or experiment with new ideas. True, there was progress during the period, but much of it was confined to the best farmers on the best land. For the great majority it was a case of hanging on, and it called for enterprise, the long view and some of the spirit of the gambler to branch out into new ways. The tendency in times of depression is, not unnaturally even if it is not ultimate wisdom, to play safe and avoid as much expenditure as possible.

Much discussion has taken place since the war on the international level as to how agricultural production can be increased and improved in all countries. The application of proved scientific advances can make the major contribution, and to get these applied on the general run of farms it is agreed that some form of advisory service is necessary. The form of such a service and how it will work will be dependent, among other things, on the general standard of education of the farmers of any particular country. Even in the so-called advanced countries this may show considerable variation. In our own country, with its variation in size of farms—which to some extent reflects the individual's financial standing—many farmers' formal education finished with the elementary school at the permitted school leaving age ; some had a year at a farm institute ; still fewer a two-year course at an agricultural college ; and a smaller number have had a degree course at a university. It must be agreed that some introduction to agricultural science for the young man in his mental formative period ought to make him more receptive to technical advances and more readily able to weigh up and assess their possibilities to his own farming conditions. If the whole subject is a closed book he starts off, even if he is the keen type, with that degree of handicap. The number taking a university or college course and who go into farming, as distinct from those training for posts, expressed as a percentage of the total number of farmers, is not likely ever to be large, but it is interesting to note in passing that, as a percentage of the total number of students in some of our universities, the figure has been growing in recent years. For England and Wales there are now 33 farm institutes with accommodation for 1,850 students. It is estimated that this, however, still only caters for less than 10 per cent of the young people entering the industry. There is much need for an extension of some form of part-time further education for those who cannot attend a farm institute. Assuming a reasonable standard of general school education, together with facilities for some form of technical instruction, then to the extent that full advantage is taken of such opportunities lies one of the ways of cultivating the attitude of mind, ready at least to consider changes. Some of our education establishments have been running sufficiently long to demonstrate this clearly in that, in the areas they serve, " past " crops of students are farming well and have become leaders in their districts. My own view would be to lay great emphasis on this " introduction " to science or technology at this stage in the future farmer's life.

Working Farms

The majority of our farms are small, and by upbringing and circumstances the farmer runs his business on an individual basis; its organization devolves on him, but in addition he has his full share of the manual work, and as many are dairy farms, it is a seven-days-a-week job. Many of them are under-capitalized and, apart from milk with its regular income, most agricultural products need an investment of

capital which brings no return for six to twelve months, or even longer. Some degree of caution is therefore perhaps not unnatural. Where the change is simple, gradual, and the chances or risks can be reasonably calculated, there should be little justification for this excuse, but where a radical change in the system of farming is required, as it well may be, caution is natural and generally wise, although not of itself an excuse for not making the change. Even if the change contemplated can be demonstrated as likely to add to the income side of the farm accounts, it may call for further capital investment as a preliminary, and, therefore, some forms of change for many farmers are dependent on credit facilities available on reasonable terms.

The reaction to change must be influenced by what the change involves or what it amounts to. If the change only amounts to an improved variety of some crop, the adoption of a regular and balanced system of manuring or a balanced ration for some class of livestock, then assuming a reasonable return from farming and the proven value of the change for the particular locality, it is difficult to find any reason for resistance to the change beyond " pig-headedness ". When it comes to major changes on the livestock side of farming, and especially with the slower breeding species, many factors may be involved. For the man who is a keen breeder of cattle and has to start with commercial animals and grade up to pedigree, it is an interesting but long road, and apart from money considerations, unless he is very fortunate or very long-lived, he is unlikely to manage more than one breed in a lifetime if he wants really to establish his herd. This, of course, does not preclude the possibility or need for other changes within the system of management in feeding or in many other aspects. To take another example, the sheep farmer in exposed hill country is governed by the need to have a breed of sheep in which hardiness and the ability to live under the prevailing conditions with the minimum of supplementary feeding must be a *sine qua non*. But again this leaves scope for adoption of improved techniques ; the introduction of some hardy cattle to improve the grazing ; the making of some silage or hay ; adoption of measures to improve animal health, etc. Nevertheless, under these conditions the farmer will naturally and rightly be suspicious of suggestions of change which do not realize the fundamental needs of his system and conditions of nature under which he operates—and not all the suggestions which have been put forward measure up to this criterion.

Farming is a complicated business and becomes more so as production is increased and intensified. The farmer must be a business man, able to organize and control labour, which doubtless includes being a bit of a psychologist. He must be something of an engineer, with the rapid growth of mechanization on the larger farms ; something of an economist to interlock the departments of his farm into an efficient whole and maintain the right balance between investment of capital and return of total output. He must be a craftsman, on the smaller

farms able to carry out himself any of the farm operations, and even if this manual proficiency is not essential on the larger farms he must know how they should be done and what constitutes a fair day's work. Add to all this that it is an advantage to have some understanding of the basic sciences underlying agriculture. Where the farming enterprise is large it can carry sectional managers, foremen or head stockmen who can share the load, but for the small- or medium-sized farms it must fall almost entirely on the farmer himself, who, let it not be forgotten, has usually his full share of manual labour to perform daily. It would be unrealistic to expect all farmers to be able to keep up to date in all the aspects of present-day farming. How many of us could claim to do so in our own subjects or at least in subjects related to and bearing on our own ? It is the realization of this fact that is the reason for the existence of advisory services, public or private. The deep reasons which make one man easily receptive to advice or suggestions and another more difficult I must leave to the psychologists, but it is the bread-and-butter job of the Service to which I belong to try and find ways and means of making suggestions and offering advice to as many farmers as we can—and in such a way as to get them adopted. The advice must be sound, proved, or where it is " experimental " in character that must be clearly understood by the farmer, and the scale of adoption or trial adjusted to the degree of risk.

It would require a separate paper to discuss this question, but I only wish here to put forward a few points which I think bear on our discussion. The reaction to advice or suggestion is often determined by whom and how the advice is offered ; bear in mind the very varying educational background of farmers. If the problem appears to the farmer as clearly " scientific ", that is, if it concerns animal disease, a crop disease or pest, or analysis of soil or feedingstuffs, he does not necessarily expect that any specialist brought in for the purpose should know all the details of practical farming. When, however, it comes to overall planning or reorganization of the farm, or even less drastic changes which affect the practical running of some section of the farm, advice from the " practical " man ranks high. It may be from a neighbour recognized as a better, more progressive and more successful farmer, or it may be from the County or District Advisory Officer. In the latter case all I want to emphasize here is that the officer must have been long enough in his area to have built up a reputation and obtained the confidence of the farmers. For a great many farmers, as for other groups, suggestion can often be conveyed through the eye more successfully and quickly than through the ear—seeing is believing. New methods applied successfully on one farm which can be seen and demonstrated to neighbours is one of the surest ways of increasing their adoption—these may be single and simple, such as the effect of a fertilizer, a crop variety, a grass seed mixture or, as we are now attempting on a number of what we call " pilot " farms, the concentration of advice on the management of the farm as an enterprise.

Advice Where it's Wanted

No series of comments ever applies equally to all members of any group, and farmers are no exception. Taking the very top section, I wonder if any other comparable section is more receptive to new ideas, more on the look-out for things to try, and if the method or technique is not yet proven and contains some degree of gamble, it only adds to the attraction. There would be no problem if all farmers fell into this section. In England and Wales a continuing survey of farms is in being in all counties, primarily designed to ensure that advice is directed to those farmers who most require it—but may not always seek it on their own initiative. It has become the practice to divide farmers into categories labelled A, B, C, but this is not claimed to be more than an approximate classification. The A farmer—assuming he is properly in that grade—is in the top section ; he is continually looking for improvement, seeks advice when he does not know the answer or wishes to discuss and have a second opinion on his proposals—here the difficulty may be that science has not yet provided an answer. B is the middle group, and therefore contains not only the average but those in all intermediate stages from that line upwards and downwards. It is the group from which the greatest increase to the nation's larder can come and the one which presents most of the problems as to how to present and persuade the individuals in it to accept and try out improved practices. C is the tail-end and the reasons for inclusion in the group are many and varied. It may be mental or physical incapacity, sheer ignorance, obstinacy, pig-headedness, call it what you will. Some can and have been helped out of it, but where a man consistently stays at this level he is beyond the scope of advice or reception to new ideas and his removal from the farming scene may be a potent influence in the adoption of improved methods by neighbours who may feel that their own standard is not much higher than that of Mr. " X ". In the war-time survey or " Domesday Book " of 1939-40 the surveyors were required to give reasons when they placed a farmer in the bottom category, and I remember one report which read " Old age and lack of experience ".

I have been engaged in one or another phase of agricultural education and advisory work for over thirty years, and, while admitting much progress is still necessary, it would be unjust on my part if I did not record the very great strides which the farming community as a whole has made in its attitude towards scientific or technical work, and their willingness—indeed, keenness—to hear about, see and discuss the results of that work ; and when convinced by demonstration or otherwise, to adopt those improvements suitable to individual systems and environments. The pace and volume of research and experimental work has been greatly accelerated during that period, but that would have been of little practical significance if the rate of absorption into farming practice had not at least to a considerable extent kept pace. To take a few examples at random: how much seed corn was dressed

against Bunt thirty years ago ? For practical purposes, none, whereas, today it is estimated that two-thirds of the cereal acreage in Great Britain is so dressed, either by the farmer or the merchant, and in East Anglia we estimate that 90 per cent of the wheat acreage is dressed. Contrast again the present position in agriculture and horticulture of the use of chemicals in the control of weeds, insect pests and plant diseases with the copper sulphate, Bordeaux mixture and lime sulphur era of thirty years ago. On the animal husbandry side, artificial insemination, unknown in ordinary farm practice before 1939, has developed so rapidly that in England and Wales for the year ended March 1951, nearly 760,000 cows were inseminated, accounting for 20 per cent of our cattle. The rapid increase in mechanization and many other examples could be quoted.

Until recent years, in all the posts I have held it has been one of my responsibilities to manage a farm, and if this did not involve my own capital it had the other stimulus that the accounts had to be audited, submitted to a Governing Body and the results announced. I have had a foot in each camp—the scientific and practical farming—and as the great majority of our farmers are small-scale capitalists, I have full sympathy with their first reaction to a change—Will it pay ? If the answer can be a reasonable, even if qualified, affirmative, then subject to some of the qualifications discussed earlier and having regard to the national need for high farming, I think we can expect that the majority of farmers will be open to the consideration of new methods. For the others, pressure of some kind may be the only answer.

PLANT GROWTH AND ENVIRONMENTAL CONTROL

A REVIEW OF CONTRIBUTIONS TO THE XIII INTERNATIONAL HORTICULTURAL CONGRESS

R. T. PEARL

National Agricultural Advisory Service

The Thirteenth International Horticultural Congress, which was held in London on September 8-15, 1952, had no one theme underlying its deliberations, but covered a range of subjects within the general orbit of developments in the horticultural sciences and their practical implications. Such was the wealth of material surveyed that, if nothing more was done in this article than to give the authors and titles of the 140 or so lectures and papers presented, it would occupy three-quarters of the available space.

Speakers drawn from twenty-six different countries, dominions and dependencies were probably heard by horticulturists and scientists of some forty nationalities. Speakers from the United Kingdom, as the sponsoring country, naturally presented the largest number of papers (40 per cent), followed by the U.S.A. with 15 per cent, Netherlands 10 per cent and France 8 per cent.

Since the last Congress in London (the IXth Congress) twenty-two years ago, advances in pure and applied physiology have unquestionably brought some fields to the fore, and none more so than the problem of plant growth and its internal and external regulation. Indeed, " Environmental Control " was the subject of one of the seven sections into which the Congress divided. As this is one of the least exploited aspects of scientific knowledge so far as horticultural practice is concerned, the present review will deal exclusively with some of the contributions made in this field.

It is perhaps thought provoking that, with all that has been learnt of light, temperature and water control, these discoveries have as yet hardly touched the fringe of traditional glasshouse and market-garden practice. Perhaps this Congress may focus attention on what is involved in exercising control of environment by means of protective structures and otherwise.

Practical Importance of Growth Principles

As G. E. Blackman[2] said : " It should be obvious that where control of environment is possible, as for example under glass, effective control depends on knowing precisely how the principal factors operate."

F. W. Went[16] reminded us that horticultural production has spread over most of the agricultural areas of the world and a great diversity of climate. Nevertheless, the role of climate in plant development and crop production has not been fully recognized.

Climate is at least as important as crop variety, and methods of adjusting the climate to the plants and, conversely, of breeding plants for the local climate, should be considered.

P. Chouard[4] emphasized that, on the one hand, growth and development are governed by a complex of regulating mechanisms—the results of heredity—but, on the other hand, there is great diversity in the response to environmental factors by different plants. By a knowledge of the growth-regulating complex of each species or variety, it becomes possible to have a more exact understanding of the cultural needs of the plant and of how to bring it to perfection in the time desired.

All these are brave words, but none would claim that these problems had been solved, although a start has been made. We are thus led to hope that one path to cultural perfection may be by analysis of the external factors which condition the internal growth processes.

Nevertheless, as P. Chouard pointed out in another context[5], horticulturists neglect to use the discoveries already made in regard to photoperiod, by which it is possible to grow plants more in line with their natural responses. They are still less aware of other processes which modify the reaction of the plant to photoperiod. In other words, the duration of the light period and the processes of lighting or darkening are fundamental technical means of forcing or retarding plants, but their effective use involves relating them to the appropriate level of other physiological processes, such as temperature influences, which may modify the response.

In fact, F. W. Went[16] asks for greater recognition of temperature influence, the effect of seasonal and diurnal fluctuation in temperature (thermoperiod), which he regards as at least as important a factor in plant responses as the light period, although photoperiodism is still a more widely recognized phenomenon.

Investigation of Growth Processes

F. G. Gregory[6] reviewed historically the development of the study of growth phenomena—the central problem of growth control. Although the horticulturist is concerned with the functioning of the plant as a whole, the problem of growth cannot be discussed realistically unless it is recognized that growth is ultimately the behaviour of cell units centred in growing points (meristems).

The study of growth earlier in this century was dominated by the consideration of processes in isolation—the Principle of Limiting Factors—which has, however, not proved applicable, for growth processes are controlled not by the single factor in minimum supply, but in varying degrees by all the external factors ; yield is a product of terms depending on the levels of all the variable factors.

A very fruitful advance in growth studies has been through the development of methods of growth analysis. Suitable developmental

data, which take into account the structural factors concerned, are selected as a basis for analysis. For example, in the pioneer investigation by this method, the accumulative rate of flower production in the compound branching system of the cotton plant was analysed quantitatively as a basis for assessment of yield. By this kind of analysis, it is possible to gain information on the main growth activities of the plant.

Basically, this method takes account of the behaviour of growing points (meristems) and extension growth, and has been very successfully exploited in precise studies of growth responses in controlled environments ; for example, in A. H. Blaauw's work on storage conditions and flower development in Dutch bulbs, F. G. Gregory and O. N. Purvis with vernalized cereals, and O. V. S. Heath with onion sets.

The analysis of growth has been pursued further to include dry-weight data and area ratios of the plant (especially leaf area), from which the " net assimilation rate* " can be calculated. This had made it possible to relate the study of growth to climatic factors, nutrient elements in fertilizer mixtures and differential varietal responses. There is the further outstanding advantage that, by appropriate statistical techniques, growth can be studied in field experiments and the optimal conditions of culture disclosed.

This method of growth analysis has been very extensively applied with annual crops (as at Rothamsted), tropical plantation and field crops, and with fruit trees in root-shoot ratio and stock-scion studies at East Malling. Examples from G. E. Blackman's work with this technique are considered later.

Growth analysis has proved one of the ways in which physiology can make a major contribution to husbandry. Some of the discoveries made as a result of its use have proved quite contrary to expectation or *a priori* reasoning, such as the discovery that in barley the net assimilation rate is independent of nitrogen supply, although nitrogen addition deepens the green colour of leaves. Speaking on the development of this technique as a precision tool for solving horticultural problems, F. G. Gregory aptly quoted Dr. Johnson's dictum : " To count is a modern practice, the ancient method was to guess."

From critical studies of growth under controlled conditions, some changes in growth rate cannot be reconciled immediately with Sach's great concept (in 1865) of the Grand Period of Growth. For instance, if cell division continues unchecked, growth under optimal conditions will increase exponentially—in proportion to the growth already made—following V. H. Blackman's Compound Interest Rate of Growth. When, however, some factor becomes sub-optimal, the

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*Net assimilation rate is the gain in dry weight of the plant per unit of leaf area in unit time, due to the excess of the assimilates produced by the leaves over the respiratory losses of the whole plant, together with the mineral nutrients absorbed. The latter usually represent only 10-15 per cent of the total.

relative growth rate will fall with time. Furthermore, even when external factors would permit, unlimited development in higher plants is prevented in varying degree by apical dominance. Again, if the leaf-stem ratio falls, then the relative growth rate will also fall.

These and other considerations indicate the need for adequate growth analysis in growth studies, and without it statements about the effect of environmental factors remain largely guesswork.

Thus the path is cleared for a deeper analysis of growth, which goes below the surface of the obvious morphogenic (organ-building) processes and takes into account the main physiological processes (assimilation, respiration, water and nutrient uptake) in plants growing under controlled climatic conditions—in " phytotrons " by all means for the fortunate few who have them. Such studies would obviously include morphogenic processes such as vernalization, photoperiodism, and the role of the growth regulators is brought into the picture.

Interaction of Temperature and Day Length

With photoperiodism, it is well to recognize how little is known of effects in plants generally—only a few species have been studied. P. Chouard mentions 148, and possibly 1,000 have been surveyed in all. It is evident that the interactions of temperature and day length are all important (e.g., in winter rye and chrysanthemum). So far, no general or specific hormones have been isolated in connection with flower initiation, although there is indirect evidence for them, but it is possible that flowering may be another of the activities of auxin, due to differences in concentration under various light and temperature conditions, and, of course, light sensitive inhibitors also cannot be ruled out.

Probably one of the most challenging research problems is the indeterminate day-length group of plants, which may include some of the main florist's flowers (e.g., carnation and rose) grown under glass. A fundamental study to see whether they could be made photoperiodic might throw light on the problem of growth response to environment.

W. W. Schwabe[13] described studies of the flowering of the chrysanthemum, generally regarded as a short-day plant but sometimes flowering in long days. The results so far are rather complex and in some respects indeterminate, but he claims that a cool vernalization treatment is necessary every year for bud initiation—a process which chrysanthemums normally receive as a matter of course in horticultural production, either in the autumn or during cold frame housing. Incidentally, the vernalization effect is not interfered with by subsequent exposure to high temperature, which contrasts with the unfavourable effect on cool-stored bulbs of subsequent higher temperature. A prolonged period under long days delays bud initiation, whereas a limited period hastens it, but short days are necessary for further floral development. Bud development can also be inhibited by treatment with an auxin paste.

Although Schwabe's work is scientifically interesting, the varieties used were, unfortunately, mainly early ones of no commercial interest and possibly with some long-day propensities. It is to be hoped that further studies, particularly with late commercial varieties, may be instituted, as different varietal responses may possibly be found. In the meantime, schedules for the control of flowering on a short-day basis, at medium or high temperature according to variety, are in operation[10] in U.S.A., and some nurseries there are now advertising all-the-year-round chrysanthemum flower production.

Using the method of growth analysis by dry weight-area ratios, G. E. Blackman [2] studied the effect of seasonal light intensity and temperature on growth in some sixteen species. Optimal light-requirement varied widely with species from about ½ " normal summer radiation " in one " shade plant " up to 2½ times for an extreme " sun plant ". The optimal requirement for the tomato was about ¾ summer daylight. Light intensity under glass is always lower than in the open, which is of most consequence in the six months from October to March. The higher temperature under glass is favourable, except in high summer, to a higher leaf area ratio, which may more than offset the lower net assimilation rate except for species with a high light-requirement. Shading affects leaf area ratio very little, but it decreases root and increases stem—a characteristic particularly undesirable in seedlings intended for planting in the open, where a higher root-to-stem ratio and a lower leaf area ratio obtains.

These examples selected from Blackman's findings justify his claim that by this method it is becoming possible to define with some precision the characteristics of plants most suited to growth under glass, and to analyse some aspects of the environment at different periods of the year both inside and outside glasshouses. He goes on to say that although large differences exist between species in their reaction to climatic factors, there are also varietal differences in responses, such as the well-known fact that some lettuce varieties are superior to others for winter culture under glass (Cheshunt Early Giant and V B).

Climate and Growth

F. W. Went, dealing with experiments on the role of climate in growth, pointed out that it had only recently become possible to reproduce some elements, such as sunlight intensity and independent temperature control, but air-conditioned glasshouses and rooms make the precise study of each climatic component more practicable. At his laboratory in Pasadena (California), forty-five different combinations of environmental conditions can be provided and combined to cover a wide range of climate, and thus used to discover the more important factors and interactions for each plant.

With many plants, the effect of one or two climatic variables overshadow all the others. Light and temperature have proved to be the major operative variables, and with full understanding it may frequently be possible to modify climate by much simpler means than the use of glasshouses. For example, a high night temperature (18° C.) is necessary for the processes leading to fruit setting in the tomato. This can be simulated by darkening the plant with black cloth at 2 p.m. on warm days, and will result in improved fruit setting.

In hot climates, temperate region plants can be started in cool houses and taken outside in the cool autumn—a logical reversal of the procedure in temperate climates of giving hot-house protection of tender plants in spring and hardening off for planting out in the summer when the weather is warm enough.

Operative climatic factors other than light and temperature tend to be related to the plant's natural habitat conditions. For example, the length of the period of rainfall is effective in inducing germination of dormant seeds of some desert plants. In one instance, one inch of rain falling in 15-24 hours was optimal for germination, but the same quantity falling in 1 hour had no effect at all.

Practical Examples of Temperature Regulation

As illustrations of thermoperiodicity[16], tuber formation in the potato plant, which is often inaccurately described as a " short-day " tuber former, is related to night temperature with an optimum round 10-12° C., although light also influences tuber production. The tomato plant has a night optimum for fruit setting and growth of 18° C., but in daytime there is a temperature-light intensity complex, the optima being relatively low light intensity and temperature (10-15° C.). Size in tomato tends to decrease with increasing temperature.

With the strawberry, interaction between photoperiod and temperature is very striking. At high temperature (15-20° C.), the strawberry is a " short-day " flowerer, but it is a " long-day " one at low temperature (5-8° C.). E. W. B. Van den Muijzenberg[9] has worked out temperature-light schedules (which have been published in English) for all-the-year-round fruiting of the strawberry (Variety Deutsch Evern).

In addition to the effect of diurnal fluctuation, seasonal thermoperiodicity is shown, to quote an example, in bud development and flowering of tulip and other bulbs. For early forcing of tulips, according to A. H. Blaauw, a short period of high temperature is required at lifting time (" curing " treatment) followed by cool temperature in subsequent storage, but later stem growth and flower opening call for successively higher temperature optima (e.g., 20-8-9-13-17-23° C. successively from bulb lifting to flower-bud colouring in forced tulips).

E. C. Wassink and another[15] have followed up Blaauw's earlier work on hastening the forcing of bulbous iris (Variety Wedgwood) by a short " curing " treatment at lifting (31° C. for one week) followed by cool storage (12° C.) before planting. They consider that high light intensity (around 2,000 lux, 14-hour day) overcomes trouble with blindness in bulbs under this treatment in Holland. N. W. Stuart[14] finds that curing at 29.4-35° C. for ten days after lifting and then at 10° C. for six weeks before planting gives satisfactory forcing results with Wedgwood bulbs grown in north-western U.S.A.

The breaking of bud dormancy in some deciduous trees by exposure to a period of low temperature in early winter is considered by M. W. Black[1]. This provides another instance of climatic conditioning, since a native of the rather warmer temperate region (e.g., peach) requires a shorter period of pre-cooling than one from a colder region (e.g., apple). The tendency of peach trees to flower prematurely in a mild spell in late winter is thus accounted for, and it also shows how hardier fruit species may be protected against a similar false start. On the other hand, when the winter temperature remains too high for the buds to receive the chilling treatment, an abnormal condition arises described as " prolonged rest ". In peach, flower-bud browning and drop occur when the critical rest-breaking (chilling) temperature of about 45° F. is not experienced for a sufficiently long period.

Practical Aspects of Light Regulation

P. Chouard[5] groups plants into four main classes according to their flower-forming responses to day length ; (a) *Long-day plants*, for which long days either are necessary for or hasten flower-forming (e.g., spinach), (b) *Long-night plants*, for which long nights either are necessary for or hasten flower-forming (e.g., tobacco), (c) *Intermediate day-length plants*, in which flower-forming is prevented, delayed or reduced both by short days and very long ones (e.g., tomato), (d) *Day-length-indifferent plants*, in which the time of flower-forming is unaffected by day length ; a few can go through the whole process even if kept in complete darkness throughout the year (e.g., some spring bulbs), others form flowers at any time of year (e.g., chickweed, annual meadow grass).

The period of exposure to day length (induction period) varies according to the species from a few days to several months ; the reversal of treatment will remove the induction effect in some species in a few days, in others in many months, in still others, not at all. Some species require different day lengths at different stages. Thus chrysanthemum do better with long days during growth and short days nearer flowering. The inter-relation of photoperiod with other variable factors, especially the combined effect of temperature and day length, is fundamental.

Interruption of the long-night period by a short period of light usually annuls the long-night effect. With many " long-night flowerers " a few minutes at, say, 1,000 lux illumination in the middle of the night is sufficient to remove the flower-forming effect, but with " long-day flowerers " a longer period of night illumination is necessary, say, 30-120 minutes at 1,000 lux, to induce the flower-forming effect. Interruption of long day with a short, dark period is usually ineffective. In all these processes, special requirements vary greatly from one species to another, and sometimes with variety, and each has to be worked out by experiment or trial.

H. A. Borthwick and M. W. Parker[3] report better results from supplemental lighting of " long-day " plants (e.g., beetroot and strawberry) with incandescent filament lamps than with fluorescent ones, possibly due to insufficient red light from the latter. With the strawberry, interruption of the dark period in short days (11 hours) by a period of 20-120 minutes' light (20-40 foot-candles) near the middle of the dark period was much more effective than a corresponding increase in day length in regulating flowering and some vegetative responses. This technique of interrupting the dark period, where applicable, is a useful and cheap alternative to the expensive process of extending day length by supplemental electric light at peak-load periods.

J. W. M. Roodenburg[12] has made a comprehensive study of the basis of artificial irradiation in relation to glasshouse practice, and advocates the use of night irradiation wherever possible. Low light intensity as a means of prolonging day length is only of use at night. High-intensity light for increasing assimilation can be given day or night, but for short-day plants the expensive day lighting is unavoidable. Incandescent filament lamps give the highest photoperiodic action —better than daylight—but cause abnormal stem lengthening at night. The former effect is due to a high proportion of short-wave red light, the latter to infra-red which is absent from neon lighting. For day lengthening in winter, filament lamps are cheapest, cause no abnormal stem lengthening and give higher day temperatures useful for thermoperiodic responses.

For supplemental " intense " lighting of seedlings in winter, H.P.M.V. lamps are best and avoid drawing the plants ; they emit practically no orange-red light and therefore are much less active photoperiodically. These points are confirmed by W. J. C. Lawrence's work at Bayfordbury with tomato and cucumber seedlings[8].

The choice of the right intensity of radiation and source of light depends on whether use is to be in the day or night. Thus lettuce plants strongly irradiated by means of filament lamps at night bolted most rapidly, whereas with similar treatment in daytime they hearted most readily. H.P.M.V. lamps caused similar but much less effective responses.

Light-Temperature Considerations under Glass

J. W. M. Roodenburg[11] points out that climatic fluctuations under glass are mainly connected with the course of the sun, which causes wide differences in temperature and light, between day and night, summer and winter. Through mechanical control by heating, lighting, shading and ventilation, too much fluctuation can be corrected, but contrary to fairly widespread belief, some fluctuation in diurnal conditions under glass is really necessary. This is exemplified by the fact already accepted with a few crops (e.g., tomato) that temperature should be lower at night than during the day.

As G. E. Blackman's work shows, the interrelation between light and temperature can be quite precise in overall effect and in the development of individual organs. The more restricted but none the less existent range of fluctuation under glass is therefore an important and mainly beneficial factor in its effect on plant growth under glass as compared with outside field conditions.

In a logical sequel to P. Chouard's contribution[5], K. Post[10] of Cornell, reviewed work, including his own, in U.S.A. and elsewhere on temperature and light relationships for flower-forcing of ornamental plants. He groups glasshouse and open ground plants according to their combined critical temperature and day-length requirements as a basis for forcing practice in U.S.A. His work prompts the query as to whether similar experiments might not be useful here.

The recognition of these principles opens up the possibility of growing some glass crops more economically, of increasing yield or of reducing their time-space demands on glasshouse accommodation[11]. As W. J. C. Lawrence observed in relation to the use of H.P.M.V. lamps, such alternatives to traditional practice may represent small increases in costs, but large gains in return.

Controlling Glasshouse Climate

The problem of instrumentation for precise measurement of the components of glasshouse climate is under development by E. R. Hoare[7] at the National Institute of Agricultural Engineering. It is a necessary prelude to effective control of glasshouse conditions and the furtherance of optimal culture of crops.

E. W. B. Van den Muijzenberg[9], in a review of the development of the glasshouse throughout the ages, clearly believes that the air-conditioned, climate-controlled structure is coming into sight. It is to be the present century's contribution to progress in protected cultivation—the attainment of the highest quality as well as the highest yield in crops.

Be that as it may, he showed that better materials than glass for light transmission and heat insulation, more economical heating systems such as the revolutionary heat-pump principle, and automatic control of light and ventilation and watering are just round the corner.

But air-conditioning and exact control of the glasshouse climate may be wild and wasteful will-o'-the-wisps, unless the grower has at his finger tips equally exact knowledge of the most effective cultural conditions and the crop's responses to them.

Briefly, precision equipment calls for precision growing, and that must come through precision experiments, of which this Congress has learned so much. In fact, freely adapting Dr. Johnson to our own ends, we might say, " To count is a modern practice, but the present method is to guess."

Authors and titles of papers presented at the Congress and referred to in this article.

1. M. W. BLACK (*South Africa*). The problem of prolonged rest in deciduous fruit trees.
2. G. E. BLACKMAN (*United Kingdom*). An analysis of the effects of seasonal light intensity and temperature on the growth of plants in the vegetative phase.
3. H. A. BORTHWICK and M. W. PARKER (*United States*). Light in relation to flowering and vegetative development.
4. P. CHOUARD (*France*). Les facteurs du milieu et les mécanismes régulateurs du developpement des plantes horticoles.
5. P. CHOUARD (*France*). Le contrôle du photopériodisme dans la pratique horticole.
6. F. G. GREGORY (*United Kingdom*). The control of growth and reproduction in plants by environment factors.
7. E. R. HOARE (*United Kingdom*). Temperature measurement with special reference to frost, steam sterilisation and glasshouse climates.
8. W. J. C. LAWRENCE (*United Kingdom*). The effect of methods of propagation on plant performance.
9. E. W. B. VAN DEN MUIJZENBERG (*Netherlands*). The influence of the air-conditioned glasshouse on the growth of plants.
10. K. POST (*United States*). Temperature and flowering of ornamentals.
11. J. W. M. ROODENBURG (*Netherlands*). Environmental factors in greenhouse culture.
12. J. W. M. ROODENBURG (*Netherlands*). Irradiation of greenhouse plants.
13. W. W. SCHWABE (*United Kingdom*). Effect of temperature, day length and light intensity in the control of flowering in the chrysanthemum.
14. N. W. STUART (*United States*). Effect of storage temperatures on the forcing responses of Easter lily and bulbous iris.
15. E. C. WASSINK and L. E. A. WASSINK-VAN LUMMEL (*Netherlands*). The action of light intensity and night temperature on flowering of bulbous irises (Wedgwood) and tulips.
16. F. W. WENT (*United States*). Climate : its role and control in plant growth.

ABSTRACTS

ANIMAL BREEDING

A Genetic Investigation of Allometric Growth in Hereford Cattle. J. F. KIDWELL, P. W. GREGORY and H. R. GUILBERT. *Genetics*, 1952, **37**, 158-74.

The difficulty of obtaining quantitative measures of the conformation of meat animals has delayed the formulation of exact breeding plans for the improvement of this class of stock. The approach described in this paper appears to offer distinct possibilities of overcoming this difficulty. The authors have used the methods of relative growth, or allometry, on body measurements of Hereford bulls and heifers. Using a double logarithmic scale, various measurements were plotted against heart girth as a standard, and it was found that if measurements at birth were excluded, those at 4, 8, 12 and 16 months could all be joined by a straight line. For the period 4-16 months, the relative growth of an individual animal can therefore be described quantitatively by this line, which in turn can be defined by two constants representing the slope of the line and the intercept on one axis. Using the values obtained for each individual, the authors proceeded to estimate the heritability of each constant from the correlation between half-sibs. In general, they found that the values of the constants relating skeletal measurements to heart girth were more highly heritable than those involving muscular and fatty tissue. Selection for desired values of these constants can thus be expected to change conformation in the required direction. It remains to be seen how such an assessment of conformation by measurement will compare in efficiency with purely visual judgment.

J. W. B. K.

Genetical Analysis of the Incidence of Dropsical Calves in Herds of Ayrshire Cattle. H. P. Donald, D. W. DEAS and A. L. WILSON. *Brit. vet. J.*, 1952, **108** 227-45.

Breeders of Ayrshire cattle in Great Britain have been rather disturbed in recent years by the incidence of dropsical calves. In order to place technical advice on a sound basis, an investigation of the genetical and clinical aspects of the condition has been carried out, and the results are described in this article.

The characteristic feature of the defective calf is dropsy of varying degrees. Affected calves show an excess of males. The maternal mortality is high. While individual breeders may suffer considerably, the overall low incidence (0.5 per cent in one group of herds investigated) indicates that dropsical calves were far from being a serious loss to breeders generally. The condition is due to a single autosomal recessive gene.

The gene has probably existed in low frequency in the breed for a very long time. In 1923, some cattle exported to Finland appear to have taken it with them. When, however, it was carried by one or more animals that became significant in breed history, its subsequent spread was inevitable. With breed structure as it is, any deleterious recessive gene, becoming frequent in the chief herds, can be expected to multiply first in the upper strata of the breed, and then increase in the lower. Some time after a decrease in frequency in the former, it will decrease in the latter. At present, the frequency of the gene is probably still rising in the mass of the population. Whether it is yet diminishing in the foremost pedigree herds is a matter for conjecture. In the event of the gene being associated in some way with a desirable character, it could conceivably be maintained at a greater frequency than formerly, through preference for heterozygotes for breeding. Apart from this possibility, the frequency should gradually decline owing to the elimination of the homozygous recessives, unless some important animal with many descendants again happens to be a heterozygote. In such a large population of Ayrshire cattle as now exists, it is unlikely to disappear altogether. Since heterozygous cows are often eliminated by death at parturition, the rate of decline in frequency should be increased over that appropriate to a recessive lethal. One extensively-used heterozygous bull, however, under present circumstances, could more than offset the natural rate of elimination.

The danger of spreading the gene through artificial insemination is real enough, but there seems no point in allowing this to obscure the fact that so long as bulls for A.I. are purchased from pedigree breeders, the real source of danger lies in the hierarchial nature of breed structure. This danger affects the whole breed, and not just the portion using A.I. Furthermore, the large scale of the A.I. organizations permits those in charge to take effective steps to reduce the danger of spreading undesirable genes by appropriate testing of young bulls.

As things are in Britain, there is not much a breeder of Ayrshire cattle can do to avoid dropsical calves beyond : (*a*) slaughtering a bull which sires them ; and (*b*) seeking, with whatever information he can glean, bulls whose ancestors at least two generations back have not produced affected calves. Breeders who have cows known to have had a dropsical calf could use them to test young bulls. Negative results from less than eight such cows would not be highly conclusive, but positive results would.

A Regional Approach to Problems of Fertility and Breeding Efficiency in Dairy Cattle. S. A. ASDELL. *Report of the Second International Congress of Physiology and Pathology of Animal Reproduction and of Artificial Insemination*, 1952, **2**, 7-16. Copenhagen.

The inheritance of breeding difficulties is under investigation in Connecticut, New Jersey, and New York States. This article emphasizes the difficulty of giving statistical values to such contrasted factors as relative ability to conceive and complete inability to do so. Most of the regional work has been done on cows that do conceive eventually, and the figures in the following table have resulted.

Repeatability and Heritability of Breeding Efficiency in Dairy Cattle

Factor Examined	Repeat-ability	Herit-ability	Nature of Data
Non-returns to first service	0.027	0.004	A.I. non-returns ; paternal half-sibs
Calving intervals	—	0.00	
Regularity of heats	0.18	0.05	U.S.D.A. Beltsville herd ; dam-daughter comparisons
Services per conception ...	0.12	0.07	
Days from first service to conception	0.11	0.07	
Calving intervals	0.07	—	New Jersey Station herd

The low repeatability and the low degree of heritability (practically zero) indicate that, with present methods of selection, little can be done to improve breeding efficiency. Indeed, if it has to be done at the sacrifice of selection for other economic factors with a higher degree of heritability, such as milk yield and fat content, it might do harm. Opposed to these results, however, is some further New Jersey work which shows that the daughters of four different sires in one herd differed significantly in breeding efficiency.

An index of breeding efficiency has also been evolved based on the interval from first breeding to third calving of the individual concerned, compared with that of the herd or breed average. Using this index, a significant negative correlation between breeding efficiency and life time yield was found for the Ayrshire breed, but not for Guernseys, Holsteins or Jerseys. The numbers of cows, however, was small in all the breeds.

Since the workers in this project have excluded most of the absolutely sterile heifers, possibly its chief value lies in its emphasis on the environmental component of sub-fertility.

G. B. Y.

SOILS

Nitrogen in Soils

Work by J. H. Hamence on the availability of nitrogenous fertilizers when added to soils was described in No. 14 of this JOURNAL, 1951, **4,** 80. Hamence (*Analyst*, 1951, **76,** 907) has continued his work by applying the technique of determining the nitrate nitrogen produced in 21 days by mixing the fertilizer under test with soil under conditions which give the maximum rate of nitrification, and comparing the results with those given by dried blood, which is taken as a standard.

The method has been extended by measuring the degree of nitrification attained at three fixed intervals of time in 21 days, or for some slowly acting materials over a longer period.

Seven main classes of fertilizers have been examined. These are: protein by-products; protein and bone by-products; treated protein residues; seed and plant residues; excreta; synthetic compounds; other fertilizers.

PROTEIN BY-PRODUCTS. Nitrogen content 10-15 per cent. These include dried blood, hoof-and-horn, shoddy and gluten. The rate of nitrification of these is fairly rapid for the first 10-12 days and then gradually falls off, until at about 60 days nearly all the organic nitrogen can be recovered as nitrate.

PROTEIN AND BONE BY-PRODUCTS Nitrogen content 2-10 per cent. The chief materials in this class are meat and bone meal, fishmeal, bonemeal and steamed bone flour. These materials nitrify at about the same rate as those in the above class when the predominating material is protein, such as the fish and meat meals, but the bonemeals have an availability of nitrogen of only 14-18 per cent.

	N *per cent*	Availability (*dried blood*=100)
Meat and bone meal	8.57	104
Fishmeal	10.67	131
Bonemeal	4.19	18
Bonemeal	3.75	14
Steamed bone flour	1.64	80

Extension of the period of the test differentiates bonemeal from very slow-acting materials, such as plastic by-products, since with time the rate of nitrification of the former increases whereas that of the latter remains steady. Steaming increases the availability of the nitrogen in bonemeals and bone flours by making the protein more readily decomposable.

TREATED PROTEIN MATERIALS. In the previous paper (*J. Sci. Food Agric.*, 1950, **1**, 92) it was shown that tanned leathers had almost no availability, whereas treated leather meal was a moderately useful material. The rate of nitrification of the latter rose fairly rapidly for the first seven days, but thereafter slowed considerably. Representative specimens examined were :

	N *per cent*	Availability (*dried blood*=100)
Bark tanned leather	5.07	nil
Chrome tanned leather	8.38	8
Treated leather meal	6.67	46
Casein waste	13.38	30
Comb dust	12.05	53
Keronikon	13.30 - 15.03	46 - 53

SEED AND PLANT RESIDUES. These consist largely of residues of oil-bearing seeds after pressing. Their quality as fertilizers varies with the species as the table below shows :

	N *per cent*	Availability (*dried blood*=100)
Castor meal	4.75 - 5.47	96 - 108
Cotton seed meal	5.62 - 5.74	36 - 39
Rape seed meal	5.16	69
Cocoa shell	2.68	nil
Dried grassmeal	1.95	nil

Examination of the process of decomposition in the soil of cocoa shell and dried grassmeal shows how the nitrate already present in the soil is used up by the bacteria which break down the carbohydrate, and so leads to a negative nitrate balance.

EXCRETA. In this class fall some of the most readily nitrified of all fertilizers, such as urea and bird guano, and some of the less readily nitrified materials such as sewage sludge.

	N *per cent*	Availability (*dried blood*=100)
Urea	46.6	170
Bird guano	16.8	163
Fresh horse manure	1.46	nil
Sewage sludge	2.14 - 3.04	14 - 34

The high value placed on bird guano in horticulture is demonstrated. Fresh horse manure, like grassmeal and cocoa shell, strongly depletes soil of nitrate nitrogen during the process of decomposition, and thus this work supports the practice of fermenting horse manure before use. The rate of nitrification of sewage sludge falls off with time.

SYNTHETIC COMPOUNDS. These include sulphate and nitrate of ammonia, which have high rates of nitrification as one would expect, and cyanamide which differs from most of the materials examined in acting slowly for the first 12-14 days and then becoming much more rapidly nitrified. Its relative availability is 84.

MISCELLANEOUS. Hop manure, which frequently consists of spent hops reinforced with sulphate of ammonia, has an availability of 128 whereas peat yields a small amount of nitrate nitrogen at 16 per cent availability.

The chief drawback of the incubation test is that it takes between 21 and 70 days, but it has been found by Hamence that a rapid laboratory test giving excellent correlation with the incubation test (except with urea-formaldehyde plastics) is the determination of the pepsin digestibility test, frequently used for measuring the percentage of available protein in feedingstuffs.

J. B. E. P.
W. M. D.

MACHINERY

An Investigation into the Change of Volume of Various Crop Materials by Chopping Them. *N.I.A.E. Technical Memorandum No.* 60.

Various crop materials were chopped by means of a flywheel-type cutter-blower, and also by a toothed-cylinder-and-concave type of shredder, and measurements were made of the space occupied by the material before and after chopping or shredding by these machines. In the case of fresh sugar beet tops, the chopped and unconsolidated material occupied only about 36 per cent of the space of the unchopped, while the chopped and consolidated material required only about 27 per cent as much room as the unchopped. Similar results were obtained for wilted beet tops and marrowstem kale. There was little difference in effect between the two types of choppers when dealing with these crops. Short grass behaved quite differently. The chopped material took up slightly *more* space than the unchopped, although the chopped and consolidated crop needed only about 70 per cent of the space. A chopped oat and vetch mixture was intermediate between the succulent crops and the short grass, occupying 65-82 per cent of the volume after chopping, and appreciably less after consolidating.

Results are given in tabular and histogram form for the materials mentioned and for swedes and baled wheat straw.

Transfer of Moisture from Damp to Dry Wheat in Storage. *N.I.A.E. Technical Memorandum No.* 71/*GD*/52.

This report describes an experiment carried out on a laboratory scale to determine the rate of transfer of moisture from wheats of various moisture contents to dry wheat mixed with them. From the results obtained it was concluded that mixing with dry grain is an effective method of drying grain having a high moisture content. Using wheats with a moisture content difference between dry and damp samples of 14 per cent, it was found that the damp sample dried at a rate of over one-half per cent per hour in the first 12 hours after intimate mixing. The rate of transfer subsequently decreased steadily as the two grain samples approached one another in moisture content. Sixteen days after mixing, the moisture contents of the two samples had still not reached equality, but the samples were uniform enough for most practical purposes. The work suggested that the humidity of the intergranular air reached equilibrium value for the mean grain moisture contents of the wet and dry grain within 3 minutes of mixing. Further work is needed to confirm this, but if the observation is confirmed, damp grain can be freed from serious danger of moulding as soon as it is mixed with the appropriate quantity of dry grain.

Silo Ventilation Employing Waste Heat from an Internal Combustion Engine.—*N.I.A.E. Technical Memorandum No.* 69/*GD*/52.

Another N.I.A.E. memorandum deals with experiments carried out at Silsoe using the waste heat from a single-cylinder diesel engine of 5 B.H.P. to drive a paddle-blade fan for the ventilation of one or more of three silos. Seventy tons of corn were satisfactorily dried in this way from 20 to 15 per cent moisture content. The average temperature rise of the ventilating air ranged from 8.6 to 9.5 ° F., and it was calculated that with diesel oil at 1s. 3½d. per gallon, the fuel cost per ton of grain dried was about 3s. 11d. Total running time was 747 hours. The performance agreed very well with calculations made in the early part of the memorandum. No difficulty was found in practice in securing the required temperature rise for the ventilating air. In fact, it was necessary to discard some of the waste heat available in order to keep the air temperature within the desired limits.

C. C.

Growing Blueberries in Oregon. C. A. Boller. *Bull. Ore. agric. Exp. Sta.*, 1951, 499.

The cultivation of blueberries (*Vaccinium* species) began about thirty-five years ago in New Jersey, where they are native, and during the last twenty years they have become an important crop in New Jersey, Michigan and other eastern states of the U.S.A.

The first plantings in the north-west were also made about thirty-five years ago but they attracted little attention. In recent years, high yields and prices in the Puget Sound have encouraged other planting along the seaboard of Washington and Oregon. Blueberry growing there is, however, still in the experimental stage, and the advice given in this bulletin is tentative.

Climate and Soil Requirements. Blueberries have been successful in climates ranging from the warm, moist summers of New Jersey to the cool, dry summers of the Puget Sound region. Near the coast of Western Oregon, the summer temperatures seem too low in some places; the fruit matures late and yields have not been high. Blueberries are moderately susceptible to spring frost damage.

In the east the typical soil is a mixture of sand and peat with a water table from 1–3 feet below the surface. The high acidity of such land is less important than aeration, moisture supply and fertility, and these can be supplied by deep sawdust mulches, irrigation and liberal applications of ammonium sulphate, which is also of special value in increasing soil acidity. Calcareous soils are not recommended. Suitable soils should be loose and well-aerated in the top foot at least, either as a result of light texture or of good structure in a heavier soil. Soil conditions favourable to rhododendrons and azaleas are also favourable to blueberries.

Mulching has proved valuable on the less suitable soils. Fir sawdust, which is plentiful in Oregon, is considered excellent and is applied to a depth of 6–8 inches. At the Oregon Experiment Station such a mulch settles at the rate of about three-quarters of an inch per year.

Irrigation is considered essential in Oregon, and is usually applied by sprinklers at the rate of about two inches of water every two weeks during dry weather.

Cultivation. The five most popular varieties are Jersey, Stanley, Pemberton, Concord, and Dixi. Two varieties should be included in each planting to ensure cross-pollination but additional varieties help to spread the picking season.

Strong two-year-old or three-year-old plants do best. It is usual to allow 8–10 feet between rows with 4 feet between plants in the row, but some plantings are at 8×8 feet or 8×6 feet and, in these, cross-cultivation is possible. An arrangement of two rows of one variety followed by two rows of another facilitates cross-pollination.

On mineral soils with a sawdust mulch, $\frac{1}{2}$ lb. sulphate of ammonia per plant per year is suggested. It is applied in early spring on the surface of the mulch in a wide ring around the plant. On organic soils, phosphorus or potassium or both may be more important than nitrogen.

Most blueberries tend to overbear, and pruning consists chiefly of cutting out a proportion of the old stems, choosing those that are crowded with weak laterals. Newly-planted bushes should be prevented from bearing fruit during their first three years or so by stripping off the blossom clusters as they appear in the spring.

Oregon being a relatively new area for blueberries, pests and diseases are not yet important.

HARVESTING AND MARKETING. Each variety requires from two to five pickings at weekly intervals, the season extending from early July to the end of August. Picking is done by cupping the hand under a cluster and lightly stripping off the ripest berries with the fingers. Both hands are used and the fruit is put into berry " hallocks " (a type of punnet) in a carrier strapped to the picker's waist. The fruit is either sold direct without further handling or graded at the packing shed, each hallock being covered by transparent paper held in place by a rubber band. Some of the berries are sold as fresh fruit and others are canned. Freezing has not yet proved very useful.

H. B. S. M.

GLASSHOUSE CROPS

Effect of 2, 4-Dichlorophenoxyacetic Acid Vapour on Tomato Plants in a Greenhouse. SANFORD and DAVIDSON. *Sci. Agric.*, 1951, **31,** 8.

In September 1948, tomatoes about 3 feet high, and certain other plants growing in an Edmonton (Alberta) greenhouse, showed distorted foliage. The upper tomato trusses were sterile; the lower trusses were fertile, but the fruit was undersized, uneven and much more pointed than normal for the variety. The injury was caused by fumes of 2, 4-D accidentally spilt on the wooden floor of a building adjoining the greenhouse. In the following season, tomato plants in the same house showed similar symptoms—seventeen months after the chemical had been spilt—and it was found necessary to replace the contaminated portion of the floor. The source of contamination of the air in the greenhouse was located by germinating cucumber seeds moistened with water through which air from different parts of the building was pumped.

Effect of 2, 4, 5-Trichlorophenoxyacetic Acid (2, 4, 5-T) Vapour on Tomatoes. *The Grower*, 1952, **38,** No. 6, 245.

Although used at a strength of 1 in 200 for killing weeds, in some cases 50 feet away from crops, the vapour had a severe crippling effect on some

outdoor crops and on some 500 tomato plants, which at the time of application were covered with glass. The vapour, which is not particularly noticeable to the user, can penetrate glasshouses and can travel considerable distances with damaging effect. It should be used with even greater caution than sodium chlorate.

Other references to injury to glasshouse tomatoes caused by fumes also appeared in *The Grower*, 1952, **38,** No. 5, 223, and 1952, **38,** No. 7, 302. In the former case, no specific material was mentioned. A "closed can of concentrated hormone weed-killer" was stood for a few days during warm weather in a mixed house. A week or so later tomato foliage twisted unnaturally, while grape-vines produced serpentine shoots and peculiar leaves. In the latter issue, the writer reports that when 2, 4, 5-T was used earlier in the year on bindweed, the vapour spread across the ends of four houses and almost finished off the tomato plants. By August they had recovered a little, but very few tomatoes had been picked from them and the tops were very thin.

E. S.

NUTRITION OF HORTICULTURAL CROPS

Molybdenum

The advances in our knowledge of the micro-nutrient, molybdenum, are now considerable. The following abstracts indicate recent trends of experimental work.

Molybdenum Nutrition of Crop Plants. II. Plant and Soil Factors Concerned with Molybdenum Deficiencies in Crop Plants. C. M. JOHNSON, G. A. PEARSON and P. R. STOUT. *Plant & Soil*, 1952, **4**, 178–96.

An investigation into the relative aspects of molybdenum deficiency in 30 crop plants is described, with tentative suggestions regarding the extractive capacity and physiological requirements of crops. The crops were grown on a molybdenum-deficient soil derived from a Serpentine formation. None of the 7 legumes or 5 grasses grown showed any need of the micro-nutrient; the remainder, including tomato, squash, broccoli, kale and cabbage, all required the addition of molybdenum.

Analytical data of the molybdenum content of seeds and foliage showed that seedborne molybdenum was sufficient to allow some of the legumes and cereals to grow normally. The seedborne molybdenum content of some species in these two groups, however, was so low that the extractive capacity of the crops must have been reasonably efficient.

Comparisons of the molybdenum content of the leaves of the different crops showed that some species require more than others for optimum growth. The cereals contained 0.03–0.07 p.p.m. molybdenum, whilst tomatoes, sugar beet, squash and spinach contained 0.1–0.2 p.p.m. molybdenum.

There were no visual symptoms of molybdenum deficiency in the legumes or cereals grown without supplementary molybdenum. The

addition of the micro-nutrient to the soil caused no growth increase, although the molybdenum content in the foliage was raised.

The remaining crops showed varying degrees of symptoms when grown without supplemental molybdenum. The addition of molybdenum caused an increase in growth and a decrease of nitrate nitrogen in the leaf.

Deficiency symptoms in tomato, squash, broccoli, kale and cabbage were characterized by interveinal chlorosis. Distortion of the leaf blade was noted in cauliflower, whilst cupping and curling occurred in leaves of tomato, buckwheat and sugar beet.

Molybdenum as a Plant Nutrient. III. The Effects of Molybdenum Deficiency on Potato, Carrot, Radish and some other Crops. E. J. Hewitt. *Ann. Rep. Long Ashton Res. Sta.*, 1951, 54–7.

Experiments were carried out in sand culture using molybdenum-deficient solutions on a range of crops including potato. Symptoms of molybdenum deficiency in potato, swede, radish and red clover are illustrated.

Potato plants may require two years' growth under molybdenum-deficient sand-culture before showing deficiency symptoms. Symptoms in the potato were characterized by pale foliage, followed by a golden chlorosis ; leaf margins curled upwards developing necrotic patches followed by withering of the leaflets. Death of the growing point occurred and lateral shoots developed ; yields were reduced.

Sugar beet plants developed interveinal chlorosis followed by scorching. Symptoms in the swede were characterized by chlorosis followed by leaf distortion comparable to " whiptail " in cauliflower. Radish showed pronounced interveinal chlorosis succeeded by marginal cupping and withering of the older leaves. Carrot foliage became pale green, and scorched along the segments. Leaves eventually withered and died. It is pointed out that these latter symptoms are not specific for diagnostic purposes.

The Control of Molybdenum Deficiency in Lettuce under Field Conditions. W. Plant. *Ann. Rep. Long Ashton Res. Sta.*, 1951, 113–5.

Lettuce grown on a molybdenum-deficient soil (*p*H 5.2) showed specific deficiency symptoms which were eliminated by corrective treatment.

The syndrome of molybdenum deficiency observed comprised chlorosis, necrosis, stunting of growth and lack of " hearting ". The texture of the leaf was " papery " and almost translucent. The deficiency was corrected by raising the soil *p*H by liming or by the addition of sodium molybdate at 2–4 lb. per acre. Yields on the control treatment (32 cwt. per acre) were increased to 64 cwt. per acre by the addition of sodium molybdate or lime.

The molybdenum content of deficient lettuce leaves was 0.06 p.p.m. Healthy leaves resulting from the corrective treatments contained 0.08–0.14 p.p.m. molybdenum.

W.P.

VEGETABLE CROPS

Experiments on the Irrigation of Sugar Beet. H. L. PENMAN. *J. agric. Sci.*, 1952, **42**, 286-92.

This paper discusses the physical principles used in four experiments described in detail elsewhere (*Ann. Rep. Rothamsted Exp. Sta.*, 1948, 1949, 1950).

It was assumed that maximum growth required maximum transpiration, and that maximum transpiration could be maintained by keeping the soil near to field capacity throughout the growing season. Transpiration rates were calculated from weather data (mean air temperature, vapour pressure, duration of sunshine, and run-of-wind), and attempts were made in the experiments to control the water content of the soil throughout the growing season by irrigation from overhead spraylines. The author remarks on the difficulty of obtaining a uniform spread of water using overhead lines ; most of the watering had to be done in late evening or early morning, and, on occasions, it was greatly delayed by having to wait for still air. The watering treatments included one set of plots left to the farmer to irrigate in his usual way. It is noteworthy that of the two very experienced farmers who co-operated, one consistently overwatered and the other consistently underwatered.

In spite of differences in season and soil, the four sets of data showed that the maximum sugar yield was obtained when the soil moisture deficit (amount of rain or irrigation needed to restore the soil to field capacity) did not exceed 2 inches in mid-July or 4 inches in mid-September.

Cultural Studies on Carrot Stecklings in Relation to Seed Production. *U.S. Dept. Agric. Circular No.* 877, 1951.

Seeding rate affected the total number of stecklings but, for practical purposes, not their size. Late sowing prevented the development of many large stecklings, while early sowing did not preclude the appearance of small ones at harvest, and it seemed almost impossible to produce a uniform crop of carrot stecklings in an unthinned seedbed. Size of steckling had little effect on viability of the harvested seed, but the larger the steckling the earlier the flowers and seeds were produced. Medium and large stecklings gave better stands of plants than small ones. Where small stecklings had to be used, it was found advantageous to water them in. Watering-in did not affect the stand obtained from large stecklings.

The Effect of Spacing on the Growth of Sprouting Broccoli. F. W. ZINK and D. A. AKANA. *Proc. Amer. Soc. hort. Sci.*, **58,** 160-4.

Sprouting broccoli was sown in rows 13 inches apart on beds arranged for furrow irrigation. The seedlings were thinned to various distances ranging from 4 to 20 inches. At spacings below 8 inches many stalks failed to reach marketable size, while thinning to 12 inches apart reduced the yield per acre. Spacing at slightly more than 8 inches apart is recommended for Californian conditions.

A hollow stem disorder appeared to be associated with the rapid growth at wide spacings.

A Comparison of the Results Obtained in 1948* and 1949 in Experiments on Thinning with Root Crops in Cheshire, with Suggestions as to Desirable Plant Populations for these Crops. L. G. G. WARNE. *J. hort. Sci.*, 1952, **27**, 110-6.

It is apparently possible to find a range of plant populations in which, while the total yield of roots increases, the yield of large saleable roots remains unchanged. The writer gives a table showing the minimum, optimum, and maximum desirable populations per acre for beet, carrot and parsnip, and the number of plants per foot in 12-inch and 18-inch rows which will give these populations.

Row and thinning distances recommended in papers on horticulture vary considerably, but they are almost always such as would give populations less than these experiments indicate to be desirable. Thus for topped beet, recommended row distances vary from 18 to 24 inches, and thinning distances from 2 to 6 inches. In Warne's experiments, 2-inch thinning distance gives only 40-70 per cent of the theoretical number of plants, and at 18-inch spacing the population is below the minimum desirable number per acre. For parsnips 8-inch thinning distance is popularly recommended, with rows ranging from 12 to 24 inches apart. Even if the theoretical stand of plants were obtained, only rows closer than 12 inches would give the minimum desirable population. With carrots, however, 4 lb. seed per acre is often recommended, and this is probably sufficient to give a population exceeding the suggested minimum.

E. J. W.

DAIRY HUSBANDRY

Herd Fertility

The Sixth International Congress of Animal Husbandry, and the Second International Congress of Physiology and Pathology of Animal Reproduction and of Artificial Insemination, which were both held at Copenhagen last July, covered several aspects of the general problem of herd fertility. The papers at both Congresses were published in a number of volumes, and while much of the material is mainly of direct interest to research workers in physiology, veterinary pathology and nutrition, the lessons which can be applied in animal management are of considerable importance. The following note is intended to give an impression of the theme of the discussions without giving detailed abstracts. Those directly interested are advised to see the original papers.

* The 1948 work was reported in *J. hort. Sci.*, 1951, **26**, and reviewed in this JOURNAL (No. 16, p. 170).

Without much doubt the contribution with the greatest potential for later development in milk production was that of the British workers Polge and Rowson. They described a technique for the successful storage of bull semen at very low temperatures (−79° C.) which permits the survival of the sperm and its use in artificial insemination after very long periods.

The exact nature of the infertility which appears to be common to all the important milk-producing countries of the world, cannot so far be defined. Disease, incorrect management, faulty nutrition and physiological defects all play their part, but it would be difficult to appraise the importance of each of these factors from a study of the papers presented at Copenhagen. It is even more difficult to propose a management formula for the protection of the dairy herd against infertility.

Vibrio Foetus as a Cause of Infertility

Certain points, however, are worth noting. The first is that the disease Vibrio foetus is becoming increasingly recognized as a common cause of failure to conceive in dairy cattle. From the dairy farming point of view, the mode of transmission from animal to animal is of great importance. Previous reports from Connecticut (*Conn. Bull. No.* 281, Dec. 1951) indicated that infection can spread direct from one cow or heifer to another. On the other hand, at Copenhagen, Sjollema, in an interesting discourse on the occurrence and control of Vibrio foetus in the Netherlands, apparently accepted the premise that the disease is spread from cow to cow by the bull. If the investigations at present in progress in a number of countries eventually show this to be the case, a successful control would appear to depend on the dairy farmer's ability to keep reliable service records, and to completely segregate the service programme of animals free from Vibrio foetus from the programme of animals thought to be infected. This can be done without segregating the female stock into two herds. Incidentally, Sjollema and others point to the danger of spreading Vibrio foetus by the practice of trying another bull on a cow or heifer failing to hold to the first bull.

Effect of Mineral Deficiencies

A number of speakers at the Animal Husbandry Congress quoted examples of lower fertility due to deficiencies of various mineral elements including phosphorus, to which Hignett and Hignett have previously drawn attention in this country (*Vet. Rec.*, 1951, **63,** 603 ; *ibid*, 1952, **64,** 203). Overfeeding, underfeeding and deficiencies of a number of vitamins were also mentioned as causes of low fertility. In many instances it is difficult to judge whether the low fertility was merely one of the symptoms of malnutrition, or the result of a specific effect of a particular deficiency on some part of the reproductive system. Hammond provided evidence that malnutrition can, under experimental conditions, affect fertility at three stages ; (*a*) reduce the number of eggs shed, (*b*) reduce the number shed that are fertilized, and (*c*) reduce the number of fertilized eggs which develop into viable young.

Management Faults and Disease

Asdell, in reporting on co-operative work on problems of fertility and breeding efficiency in dairy cattle in the north-eastern states of America, considered that the major problems were associated with faults in management and disease rather than nutrition. This difference in emphasis as to the cause of low fertility, as compared with the views of many European workers, may, of course, be due to differences in quality and quantity of cattle food available in the two regions, but it is evident that the major management faults found in New York State may also be common in Britain. These were (1) failure to detect signs of heat, (2) serving cattle too soon after calving, say earlier than 60 days, (3) failure to detect the presence of low fertility in a bull, especially in herds where more than one are used. Asdell advised against attempts to select for breeding efficiency owing to the very low degree of heritability of this factor. His data on the effects of plane of nutrition on fertility indicated that, with young dairy cattle, a low plane of nutrition delayed the age of first heat and first conception, and resulted in more calving troubles, although the conception rate was not reduced.

A. S. F.

POULTRY HUSBANDRY

Economics of Egg Production

The increasing interest of poultry-keepers in this country today in the economics of egg production gives topical value to an American bulletin on " An Economic Analysis of 32 Poultry Cost Accounts " by J. G. Hawthorne and L. F. Miller in *Bulletin* 511 of the Pennsylvania State College, 1949. This bulletin indicates that the problems of the poultry-keeper across the Atlantic are very similar to our own ; the conclusions of the authors offer an interesting comparison between our costs and those overseas. The average annual food consumption of the birds in the flocks surveyed amounted to 116 lb. for heavy breeds and 104 lb. for light breeds ; it must be borne in mind that American strains are probably about half a pound lighter than similar breeds in this country. Labour averaged 1.6 man-hours per bird—not greatly below that required by a 1,200 bird flock looked after by one man.

Food costs amounted to 61.1 per cent of the total charges, 13.4 per cent was accounted for by labour, and 16.6 per cent by depreciation in the laying flock. The total cost per layer was $7.38 ; the gross returns, including such items as income from food bags and manure, was $8.76. In commenting on the result, the authors draw attention to the increase in returns with the increasing size of the flock.

Egg Quality

Dealing with a subject which has so far received limited attention, namely, " The Influence of Egg Shell Porosity on the Number of Chickens Hatched from Incubating Eggs" (*Poult. Sci.*, 1952, **31**, 589-94), W. Rauch demonstrates that mean pore diameter is less in fertile eggs with a high hatching rate than in eggs where hatchability is low. The author expresses the opinion that there is an optimum width of pore diameter for the exchange of gases through the egg shell. He recommends that poultry-farmers should pay attention to this characteristic of egg shells in an endeavour to improve hatchability when a low level cannot be attributed to other specific factors. The writer describes an ingenious method of determining porosity, but the system is not practicable for most poultry-keepers ; a fair rule-of-thumb method must remain an estimation of porosity based on the excessive enlargement of the air cell during incubation.

On another aspect of egg quality is the article on " Thermostabilization of Shell Eggs : Quality Retention in Storage " by H. E. Gorseline, K. M. Hayes and A. W. Otte in *Circular* 898 of the U.S.D.A., 1952. The authors give an account of the high keeping-quality of eggs which had been thermostabilized ; after seven-and-a-half months in storage 84 per cent of the thermostabilized eggs remained in first-rate condition, compared with 37.8 per cent in the case of those eggs receiving oil dipping only. Thermostabilization was carried out by heating eggs with an initial temperature of 60° F. in flowing oil at a temperature of 134° F. for sixteen minutes. The internal temperature of the eggs at the conclusion of the heated oil treatment was 122.3° F.

Growth-Promoting Supplements

A great number of papers have appeared recently on the value of the A.P.F. complex, B_{12} and antibiotics. Latterly, a few articles have been published on the value of surfactants on chick growth. The earlier claims advanced for all these substances now seem to be modified, and of late some doubt is being cast on claims that their inclusion *invariably* leads to an improvement in growth. In an article on the " Effect on Growth of Supplements to Chick Rations containing Vitamin B_{12} and Antibiotics " by M. L. Sunde, J. R. Vedvik, H. W. Bruins and W. W. Cravens (*Poult. Sci.*, 1952, **31**, 571-6), it is shown that an improved growth response was obtained when fish solubles were included in a diet already containing B_{12} and an antibiotic. The authors conclude that the solubles contain a growth-promoting factor other than B_{12} and whatever factor(s) are contained in the antibiotics (in this experiment streptomycin, aureomycin and penicillin). Similar findings are described in a paper on " A Comparison of B_{12}, Fish Solubles and Whey in the Growth of Chicks ", by H. L. Fuller, C. W. Carrick and S. M. Hauge (*Poult. Sci.*, 1952, **31**, 473-8). Fuller and his colleagues consider that the chick's needs for the unidentified growth factors are not influenced by the presence or absence of antibiotics (in this instance streptomycin).

In discussing the mass of experimental data on the use of these several growth-promoting supplements in an article entitled "The Practical Role of Antibiotics in Manufactured Poultry Feeds", 1952, *44th Proc. American Feed Manufacturers' Assoc.* (in the press), W. W. Cravens draws attention to the variable results reported by research workers. Dr. Cravens expresses the opinion that as the general growth level obtained with unsupplemented rations is improved, the growth-stimulating effect of the antibiotic diminishes. The author also draws attention to the improvement which usually results when the several supplements are used conjointly. The experimental results shown indicate that in some instances the addition of B_{12} or an antibiotic only may result in no improved growth and even depression.

Discussing the "Effect of Surface Active Agents on Chick Growth", H. M. Scott, B. C. Johnson and E. A. Goffi (*Poult. Sci.*, 1952, **31,** 746-7), refer to the recent suggestions that surfactants are capable of stimulating growth. This possibility, it has been suggested, is due either to the wetting action of the surfactant allowing greater action by digestive fluids, or by some action akin to that of an antibiotic. The authors using six types of surfactants found that in no case was growth accelerated and in one instance growth depression followed. Cases of perosis were not infrequent amongst the treated chicks.

R. C.

ENTOMOLOGY

A Disease of *Scabiosa caucasica* caused by the Nematode *Aphelenchoides blastophorus* N.Sp. MARY T. FRANKLIN. *Ann. appl. Biol.*, 1952, **39,** 54–60.

This disease of Scabious (variety Clive Greaves, much grown commercially) is characterized by the death of the young flowers and consequent blindness of the plants. The leaves are distorted with thickened midribs and often severely reduced laminae which are thicker and tougher than normal. The eelworms have been transferred experimentally to a closely related plant, the Fuller's Teagle (*Dipsacus fullonum*).

***Ditylenchus destructor* (Thorne) in Mushrooms.** J. W. SEINHORST, JR. and P. J. BELS. *Tijdschr. PlZiekt*, 1952, **57,** 167–9.

A disease known as "mushroom sickness" has been found in Holland associated with a species of eelworm closely resembling *D. destructor*, which normally attacks potato. The eelworm causes the gradual disappearance of the mycelium, and experimental infections of mushroom mycelium and of potato with *Ditylenchus* eelworms from potato and mushrooms were made. The potato tubers and the mushroom mycelium were attacked by the *Ditylenchus* from both sources. No morphological differences could be found between the eelworms from the two sources and it is therefore considered that the species attacking mushrooms is the Potato Tuber eelworm (*Ditylenchus destructor*).

A Predacious Amoeboid Organism destroying Larvae of the Potato Root Eelworm and other Nematodes. A. PH. WEBER, L. O. ZWILLENBERG and P. A. VAN DER LAAN. *Nature*, 1952, **169,** 834.

An extremely interesting amoeboid organism has been discovered on cysts of the Potato Root eelworm in the province of Gronigen, Holland. The amoebae were found attached to the outside of potato eelworm cysts in the form of hypnocysts, and the creeping forms which emerge from these hypnocysts can attack the eelworm larvae. The amoeba, starting at the head or tail of the eelworm, completely engulfs the prey, and the motionless larva can be seen lying in the protoplasm of the organism. In due course it is digested.

The matter is being fully investigated in case it might prove possible to use this amoeba in the fight against Potato Root eelworm and other nematode pests.

The Biology of the Strawberry Aphid, *Pentatrichopus fragifolii* (Cock.), with Special Reference to the Winged Form. G. H. L. DICKER. *J. hort. Sci.*, 1952, **27,** 151–78.

A very full account of recent work on the biology of the strawberry is contained in this paper, which will be of great interest to those concerned with problems of virus spread in strawberries. The host plants are discussed, also the varietal difference in the intensity of infestation. The variety Huxley normally carries the highest populations, followed by Royal Sovereign, Paxton and Early Cambridge ; Tardive de Leopold and Perle de Prague have never been noted with more than moderate populations, and Madame Lefebvre is usually only lightly infested. The variety Auchincruive Climax seldom appears to be heavily infested.

Intensive samplings of infested fields have shown that on first-year plants the aphid population rises to a peak in late summer or early autumn and then declines. On older plants, however, the peak is reached in late May or June ; this is followed by a rapid decline, and low populations persist for the rest of the year. It is suggested that the rapid decline in populations on the older plants during June is due to a reduction in the number and quality of the young leaves produced at that time as a result of fruit development.

The initial infestation of clean strawberries by the winged forms has been studied. The winged forms do not remain long on any one plant, but feed, deposit a small number of young and then fly off to repeat the process. In this way many plants are colonized at an early stage, and subsequent plant to plant infestation takes place by the wingless aphids. A plot of plants known to be free of aphids in May was examined regularly, and the sampling suggested that by the end of July almost every plant had become colonized.

Biology of some Predatory Insects and Mites Associated with the Fruit Tree Red Spider Mite (*Metatetranychus ulmi* (Koch)) in South-Eastern England. I. The Biology of *Blephariopterus angulatus* (Fall.) (Hemiptera-Heteroptera, Miridae). ELSIE COLYER. *J. hort. Sci.*, 1952, **27**, 117–29.

This paper is the first of a series dealing with the predators of the Fruit Tree Red Spider mite. It is now generally accepted that the original development of the mite as a serious pest in England was connected with the introduction of routine winter spraying with tar oil washes; many important checks of the Red Spider were killed and the mite increased. The Black-Kneed Capsid (*B. angulatus*) is the principal predator in commercial orchards, and the biology of it is fully described in this paper. Of special interest is the account of the feeding habits of this insect. Red Spider mites were fed to the Capsids and it was found that the average total number of adult mites consumed under favourable conditions was 3,248 in 1947 and 4,230 in 1948.

The Black-Kneed Capsid also feeds on aphids and many other small insects and is partially phytoplagous, though essentially carnivorous. When eggs are laid in the young apple wood, typical "bumps" are formed.

L. N. S.

MYCOLOGY

Potato Diseases

Dry Rot Disease of the Potato. I. Effect of Commercial Handling Methods on the Incidence of the Disease. C. E. FOISTER, A. R. WILSON and A. E. W. BOYD. *Ann. appl. Biol.*, 1952, **39**, 29-37.

The writers studied the effect of commercial handling on the development of dry rot in the susceptible varieties Doon Star and Arran Pilot grown in Scotland. In spite of the fact that dipping control methods are most effective at lifting time, little infection took place during lifting operations or subsequent clamping. This may be due either to the small amount of damage at this time or to the greater resistance to infection of the tubers in the autumn. Most of the infection occurred following injury by riddling through mechanical, reciprocating, bare wire screens. Hand riddling or the use of rubber-coated screens reduced the infection. There was also a marked increase in infection after mechanically-riddled seed had travelled to England; this increase was less with hand-sorted tubers. Unless tubers were roughly handled, there was little development of the disease in potato stores. Contact infection from neighbouring tubers was negligible, and it is therefore considered unwise to remove diseased tubers during the winter because

handling may lead to infection of healthy tubers. The fungus was found to enter the tubers through wounds and the lesions of blight and powdery scab but not common scab.

Dry Rot Disease of the Potato. II. Fungi Causing Dry Rot of Seed Potatoes in Britain. R. K. McKEE. *Ann. appl. Biol.*, 1952, **39**, 38-43.

An examination was made of 144 stocks of seed potatoes, and, where possible, ten tubers showing dry rot symptoms were selected from each stock. There were 40 samples of Arran Pilot, 33 Majestic, 16 King Edward, 9 Doon Star, 7 Home Guard, and 39 miscellaneous varieties. Parasitic species of *Fusaria* were present in 91 per cent of the affected tubers. Of these, 93 per cent were infected with *Fusarium caeruleum*, 6 per cent *F. avenaceum*, and less than 1 per cent each *F. arthrospoides* and *F. tricinctum*. This last fungus had not previously been recorded in Britain. It was found that *F. caeruleum* could be quickly identified if a small piece of rotted tissue was kept on moist filter paper in a Petri dish for a few days ; it then produced characteristic spores.

Dry Rot Disease of the Potato. III. A Biological Method of Assessing Soil Infectivity. R. K. McKEE and A. E. W. BOYD. *Ann. appl. Biol.*, 1952, **39**, 44–53.

Soil samples 4 inches deep, taken from at least fifty places in a field, were bulked, sieved, and a portion stored in a boiling tube. For each field two inoculations were made in each of fifty tubers of the variety Doon Star. This was done by making small holes with a glass inoculator and filling them with the soil so that the soil was moistened by sap from the damaged cells. The tubers were then incubated at 60°F., and kept covered by wet sacks. The number of dry rot lesions developing was regarded as a measure of soil infectivity. Ninety-one of the lesions occurring were due to *Fusarium caeruleum* or a few other Fusarium species, of which *F. avenaceum* was most common. It was usually possible to distinguish the lesion caused by *F. caeruleum* from the other species by the colour of the infected tissues. There was some variation in the index obtained from five different samples from the same field but this was not greater than the variation in five replicates of the same sample. The method does not give an absolute figure for infectivity but may be used to compare different soils.

Trials of Substitutes for Sulphuric Acid for Potato Haulm Killing. II. Blight in Tubers. Compiled by E. C. LARGE. *Plant Path.*, 1952, **1**, 56–9.

At eleven centres in England and Wales where trials were carried out to investigate the efficiency of various materials in killing potato haulm, samples of tubers were examined to determine the amount of blight infection. At no centre was there any significant difference between the amount of blight on the tubers from the various treatments or from the untreated control plots. Any differences between the amount of

blight at different centres appeared to be associated with cultural and climatic conditions. A high percentage of tuber infection was associated with a long, slow development of the disease on the tops, heavy rainfall during the infection period, poor earthing up, or a combination of these factors. Conversely, protective copper spraying of the tops, good earthing up, and dry conditions, were accompanied by low blight infection of the tubers. It is emphasized that these results may apply only to this one season.

The Susceptibility of some Potato Varieties to Common Scab (*Actimomyces scabies* (Thoxt.) (Gussow)) in Different Soils. R. McKAY. *Sci. Proc. R. Dublin Soc.*, N.S. **25,** 65–84.

At four centres in Eire during the years 1941–46, 65 potato varieties were tested for resistance to scab, in plots to which scabbed peelings were applied. All varieties were badly infected at one or more of the four centres. The most resistant varieties were Di Vernon (20 per cent severe scab), Ulster Chieftain, Edgell Blue, Doon Early (20–30 per cent severe scab). Golden Wonder was usually resistant but had 86 per cent severe scab at one centre. The most susceptible varieties were Up-to-Date and Majestic. Scab was worst in the driest years at the Clonakilty station, where rainfall was lowest and the soil light and gravelly. Only at this station was the continual potato cropping accompanied by an increase in the amount of scab.

H. E. C.

VIROLOGY

Gladiolus as a Virus Reservoir. G. H. BRIDGMON and I. C. WALKER. *Phytopathology*, 1952, **42,** 65.

A number of viruses have been reported as affecting the gladiolus in the U.S.A. These are the viruses of Cucumber Mosaic, Tobacco Ringspot, and Yellow Bean Mosaic. A close relationship was found between gladiolus plants which contained Cucumber Mosaic and Tobacco Ringspot viruses and those having typical white break symptoms in the flowers. The exact relationship of these viruses to white break was not determined, and attempts to reproduce the disease by inoculating them into healthy gladiolus plants were unsuccessful. (In this country the two viruses found in gladiolus are those of Cucumber Mosaic and Tomato Spotted Wilt. The first-named appears most commonly and gives rise to a break in the flower colour.)

A Mosaic of Vanda Orchids. H. H. MURAKISHI. *Phytopathology*, 1952, **42,** 178.

Vanda Mosaic virus causes white streaking and, at times, necrotic areas in flowers of V. Miss Joaquim, as well as systemic mottling, purpling, and leaf malformation. The virus only affects species of the genus *Vanda* and an intergeneric hybrid. It is sap-transmissible, but the

insect vector is not known; four aphid species were tested without success. (In certain parts of the U.S., viruses attacking orchids are very frequently met with. Jensen, in California, has worked with three viruses, one of which is aphid-transmitted. A ringspot virus is also very common.)

Some Garden Plants Susceptible to Infection with the Cucumber Mosaic Virus. KENNETH M. SMITH. *J. R. hort. Soc.*, 1952, **77**, 19.

A number of important hosts of the Cucumber Mosaic virus are given. These include lilies, anchusa, begonia, campanula, aquilegia, aster and zinnia. The wild primrose is also susceptible, and when grown in gardens is quite often affected, the leaves being narrower than normal, curved and distorted. Among woody plants and shrubs, *Daphne Mesereum* seems particularly susceptible, and a species of *Buddleia* has also been found infected. It is pointed out that a virus affecting chrysanthemums (Tomato Aspermy of Blencowe & Caldwell) has a very wide host range including *Tropaeolum*, *Phlox drummondii*, zinnia, helichrysum, wallflower, *Primula sinensis stellata*, lettuce and soya bean. On the last-named, the virus causes a severe disease.

Carnation Mosaic Virus : Properties and Electron Microscopy. R. W. AMES and H. H. THORNBERRY. *Phytopathology*, 1952, **42**, 289.

Some of the physical properties of a Carnation Mosaic virus are described. It is thought to be a spherical particle with a diameter of approximately 31 millimicrons. See also " I. Investigations on Carnation Mosaic ". D. Noordam, T. H. Thung, and J. P. H. Van der Want. *Tijdschr. PlZiekt*, 1951, **57**, 1-15.

Sugar Beet Virus Yellows in United States. G. H. COONS. *Phytopathology*, 1952, **42**, 341.

Virus yellows is now considered to be present in Michigan, Colorado, Utah, Oregon and California. This opinion is based on similarity of symptoms, aphid transmission and serological tests. The disease known in California as " Salinas Yellows " has been shown, on the basis of both aphid transmission and serological tests, to be virus yellows.

Some Relationships of Three Plant Viruses to the Differential Grasshopper *Melanoplus differentialis*. (Thos.). H. J. WALTERS. *Phytopathology*, 1952, **42**, 355.

This large grasshopper was found to transmit three plant viruses, i.e., those of Tobacco Mosaic, Potato virus X and Tobacco Ringspot. Most, but not all, the local lesions caused by the viruses developed adjacent to feeding areas on the leaves. The viruses remained infectious for several hours in buccal fluid within grasshoppers.

K. M. S.

PROVINCIAL NOTE

AN EXPERIMENT ON THE NITROGENOUS MANURING OF GRASS

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During the last three years an experiment has been carried out on a field known as Garden Field at the Experimental Husbandry Farm, Trawscoed. The object was to investigate the effect of varying dressings of sulphate of ammonia on the yields of dry matter and crude protein from four different grass mixtures. The field was directly reseeded out of permanent pasture in June 1949, and the whole area received 30 cwt. ground limestone and 4½ cwt. I.C.I. No. 1 per acre at seeding time.

The four mixtures used were as follows :

Mixture A

	lb. per acre
Perennial ryegrass S.23 ...	10
Perennial ryegrass S.101 ...	10
White clover S.100	1
Wild white clover	½
	21½

Mixture B

	lb. per acre
Italian ryegrass	6
Perennial ryegrass S.101 ...	4
Timothy S.48	3
Cocksfoot—Danish	3
„ S.26	3
„ S.143	3
„ S.37	3
Red clover S.123	3
White clover S.100	1
Alsike	2
White clover S.184	½
	31½

Mixture C

	lb. per acre
Cocksfoot S.37	13
„ S.143	5
White clover S.100	1
Wild white clover	¼
	19¼

Mixture D

	lb. per acre
Meadow fescue S.215 ...	10
Timothy S.48	8
White clover S.100	1
Wild white clover	¼
	19¼

Layout of Experiment

The experiment consisted of 3 randomized blocks of 9 treatments on each of the four grass mixtures, the size of individual plots being approximately 40 square yards. The initial treatments in the first year (1950), were 0, 2, 4, 6, 8 and 12 cwt. sulphate of ammonia per acre. In addition, duplicate plots of the 2, 4 and 6 cwt. dressings, to which an additional 2 cwt. sulphate of ammonia per acre was applied after the first cut, were included in each block. The object of this procedure was to compare single dressings with split dressings. These treatments will be referred to in the text as 2+2, 4+2 and 6+2, and over the season can be compared with the single dressings of 4, 6 and 8 cwt. sulphate of ammonia per acre respectively. All the dressings were repeated on the same plots in 1951 and 1952. The whole experimental area was given a basal dressing of 3 cwt. superphosphate and 2 cwt. muriate of potash per acre at the end of March in each of these two years.

The sulphate of ammonia was applied during the month of April : in the first year in mid-April, in the second at the end of the month, and in the third year at the beginning. It was intended that first cuts should be taken when visual examination suggested the optimum stage of growth for either artificial drying or high quality silage, but owing to the number of plots involved and other circumstances such as wet weather, it was not always possible to follow this procedure. Two cuts were taken from the plots each year, except for mixture A in 1950 when only one cut was taken. During the autumn of 1950 and 1951, the plots were grazed down by sheep.

Only the results for the General-Purpose mixture (B) will be given and discussed in the present article. The conclusions that can be drawn, up to the present, from the results for the other mixtures, are very similar, but some differences in total production of dry matter and crude protein can be observed, particularly in the case of the first cuts every year from the Ryegrass mixture (A). It is intended to continue the experiment for at least another year, and when it is completed a more detailed report on all the four grass mixtures will be produced.

As a result of the treatments and cutting, botanical changes and deterioration of the swards have occurred. Sward deterioration is very marked in the Ryegrass mixture, whilst in the General-Purpose mixture (B) and the Timothy-Meadow fescue mixture (D) the heavier nitrogen plots are gradually becoming dominated by cocksfoot, and much bare ground is apparent. Although no cocksfoot was sown in mixture D, it was observed that some was present in the sward in 1950 when the experiment was started.

Despite sward deterioration the plots still continue to give good yields of dry matter and crude protein, as can be seen from the figures for the General-Purpose mixture (B) given in Tables 1, 2 and 3.

The results show many points of interest which will be discussed in the order set out in the tables.

Table 1

Dry Matter Yields
(*cwt. per acre*)

General-Purpose Mixture

Dressing of Sulphate of Ammonia per acre *cwt.*	First Cut				Second Cut				Mean Total Yields (1st and 2nd Cut)
	1950	*1951*	*1952*	*Mean*	*1950*	*1951*	*1952*	*Mean*	
0	4.2	11.8	14.3	10.1	17.2	19.4	19.0	18.5	28.6
2	15.1	21.4	20.4	19.0	16.6	15.0	15.6	15.7	34.7
4	18.2	26.8	25.6	23.5	21.8	18.4	16.2	18.8	41.3
2+2	13.6	21.8	19.3	18.2	34.2	25.6	23.3	27.7	45.9
6	22.3	28.8	24.2	25.1	25.4	24.8	18.9	23.0	48.1
4+2	18.4	26.6	23.5	22.8	26.8	23.6	25.0	25.1	47.9
8	21.2	29.8	26.2	25.7	28.2	26.6	22.9	25.9	51.6
6+2	21.7	28.2	25.3	25.1	30.4	30.4	26.0	28.9	54.0
12	19.6	28.6	23.0	23.7	35.0	29.0	30.3	31.4	55.1

Dry Matter Yields

First Cut. The figures for the first cut show that the yield increases with increasing nitrogen, and reaches a maximum at about the 8 cwt. per acre rate. The average increase of dry matter, resulting from the addition of up to 8 cwt. sulphate of ammonia per acre, was approximately 2 cwt. for each cwt. of the fertilizer applied. The yield at the 12 cwt. level was less every year than that obtained with 8 cwt. This might be accounted for partly by the scorching effects always noticeable on these plots as a result of the heavy dressing.

Higher yields were obtained on all plots in the second and third year than in the first year. The very great increase in yield on the no nitrogen plots in 1951 was due to the increase in the density of the sward, and particularly in the clover content. In 1952 the first cut from the no nitrogen plots yielded more than three times the dry matter obtained from the corresponding cut in 1950. There were no significant differences in the yields for the first cut between the plots which had received an additional 2 cwt. of fertilizer per acre in the previous year, namely, the 2+2, 4+2 and 6+2, which for this cut can be compared with the 2, 4 and 6 cwt. rates respectively.

Second Cut. The mean results for the three years show that the no nitrogen plots gave a higher yield than those receiving 2 cwt. of fertilizer, and were about equal to the 4 cwt. plots. When considered year by year, the no nitrogen plots produced more dry matter than the 2 cwt. plots every year, more than the 4 cwt. plots in 1951 and 1952, and more than the 6 cwt. plots in 1952. This can probably be accounted for by the change in the botanical composition of the sward, and also by a progressive increase in the amount of bare ground following the addition of the heavier dressings of nitrogen. The residual effect of nitrogen which seemed to be apparent in the first year at the 4 cwt. level and above does

not appear to be sufficient at the 4 cwt. level in the second year, or even at the 6 cwt. level in the third year, to compensate for the reduction in the clover content and the general thinning out of the sward. At the 8 and 12 cwt. level, this residual effect more than counterbalances any changes in the botanical composition of the sward and reduction in ground coverage.

The effect of the split dressings on the second cuts are evident, since in all cases higher yields were obtained than with the comparable single dressing. The difference was most noticeable with the 2+2 dressing as the initial 2 cwt. would not be expected to show any residual effect.

TOTAL YIELDS (FIRST AND SECOND CUTS). The effects of the treatments on the total yields are shown in the last column of Table 1. The response to nitrogen is linear up to the 6 cwt. level and corresponds to 3.25 cwt. of dry matter for each cwt. of sulphate of ammonia applied per acre. Above the 6 cwt. level, the response is less, being 1.75 cwt. of dry matter per cwt. of fertilizer applied from the 6 to 8 cwt. level, and 0.875 cwt. per cwt. applied from the 8 to 12 cwt. level.

The split dressings of 2+2 and 6+2 gave a higher dry matter yield than the initial 4 and 8 cwt. dressings respectively, but there was no difference between the initial 6 cwt. and the 4+2.

Table 2

Crude Protein Yields
(*cwt. per acre*)

GENERAL-PURPOSE MIXTURE

Dressing of Sulphate of Ammonia per acre *cwt.*	First Cut				Second Cut				Mean Total Yields (1st and 2nd Cut)
	1950	*1951*	*1952*	*Mean*	*1950*	*1951*	*1952*	*Mean*	
0	0.7	2.3	2.6	1.9	2.0	3.5	3.2	2.9	4.8
2	2.7	3.6	3.9	3.4	1.9	2.3	2.2	2.1	5.5
4	3.8	5.5	5.0	4.8	2.2	2.1	2.1	2.1	6.9
2+2	2.5	3.8	3.6	3.3	3.8	3.9	3.4	3.7	7.0
6	5.2	6.9	5.6	5.9	2.8	3.1	2.1	2.7	8.6
4+2	3.6	5.5	5.1	4.7	3.7	3.7	3.9	3.8	8.5
8	5.5	8.1	6.7	6.8	3.5	3.8	3.2	3.5	10.3
6+2	5.3	7.0	5.8	6.0	4.0	4.8	4.2	4.3	10.3
12	5.9	8.3	6.9	7.0	5.5	4.7	5.9	5.4	12.4

Crude Protein Yields

FIRST CUT. The crude protein yields increased steadily up to the 8 cwt. level, the response per cwt. of fertilizer being somewhat greater at the lower levels, namely, about 0.75 cwt. of crude protein per cwt. of sulphate of ammonia from the 0 to 4 cwt. dressings, and about 0.5 cwt. per cwt. of sulphate of ammonia from the 4 to 8 cwt. dressings. There was practically no increase in crude protein yield for this cut above the 8 cwt. level.

SECOND CUT. The mean figures (Table 2, column 9) show that the crude protein yield of the no nitrogen plots were greater than that of the initial 2, 4 and 6 cwt. dressings. This follows a similar trend to the dry matter yields and appears to be progressive over the three years. In 1952 the crude protein yield of the no nitrogen plots was equal to that of the 8 cwt. plots. As in the case of the dry matter yields, the crude protein yields from the split dressings were higher than the corresponding initial dressing, with the greatest effect showing at the lower levels.

TOTAL YIELDS. The crude protein yields increased with the increasing nitrogen dressings. The increase was, however, not regular, being greatest and almost linear from the 2 to 8 cwt. level. Between these points, each cwt. of sulphate of ammonia per acre gave an increase of 0.8 cwt. of crude protein. The mean increase of crude protein obtained from the 2 cwt. dressing is only 0.35 cwt. per cwt. of sulphate of ammonia applied, while the increase shown by the 12 cwt. dressing over that of the 8 cwt. dressing was approximately 0.5 cwt. per cwt. of fertilizer. There was no apparent difference between the amount of total crude protein produced in the two cuts when the dressings were split. For this mixture there are, however, indications that, from the practical point of view, when considered in relation to the crude protein percentage (Table 3), it would be an advantage to split the dressings, particularly at the 6 and 8 cwt. levels, in order to get a higher percentage of crude protein in the second cut.

Table 3

Crude Protein Percentage

GENERAL-PURPOSE MIXTURE

Dressing of Sulphate of Ammonia per acre	First Cut				Second Cut			
cwt.	*1950*	*1951*	*1952*	Mean	*1950*	*1951*	*1952*	Mean
0	16.2	19.8	18.5	18.2	11.6	18.2	17.0	15.6
2	17.8	17.1	19.0	18.0	11.4	15.0	14.3	13.6
4	20.9	20.5	19.5	20.3	9.9	11.5	12.8	11.4
2+2	18.3	17.9	18.8	18.3	11.0	15.4	14.4	13.6
6	23.5	23.9	23.2	23.5	11.1	12.6	11.0	11.6
4+2	19.7	20.5	21.9	20.7	13.9	15.6	15.7	15.1
8	26.0	26.2	25.5	25.9	12.4	14.4	14.1	13.6
6+2	24.6	24.5	23.1	24.1	13.1	15.9	16.1	15.0
12	30.2	29.0	29.9	29.7	15.6	16.4	19.5	17.2

Crude Protein Percentage

FIRST CUT. The mean crude protein percentage was high in all treatments. The 2 cwt. dressing appears to have had very little effect on the percentage of crude protein. It was only when 4 cwt. per acre was applied that an increase in crude protein percentage was obtained. From the 4 up to the 12 cwt. level, the increase in percentage crude

protein is almost linear and is equivalent on the average to 1.2 per cent per cwt. of sulphate of ammonia applied.

SECOND CUT. The mean crude protein percentage gradually fell to a minimum at the 4 or 6 cwt. levels, and then increased at the 8 and 12 cwt. levels. This fall and subsequent rise in the crude protein percentage was probably governed by the complex relationship between residual nitrogen from the first dressings at the higher levels and the changes in the botanical composition of the sward at all rates of nitrogenous manuring. From a visual examination of the plots, it appears that the clover content is highest in the no nitrogen plots and decreases with increasing nitrogen application up to the 6 cwt. level, where it has practically disappeared. Furthermore, there appears to be a reduction in grasses other than cocksfoot, together with a corresponding increase in bare ground, with increasing rates of nitrogen application. This trend is progressive, and at the 12 cwt. level the sward is almost entirely composed of strong-growing cocksfoot plants with a high proportion of bare ground. The higher crude protein percentage of the dry matter from the 8 and 12 cwt. plots is due to the residual effects from the initial dressings.

The effect of the additional nitrogen for the second cut in the split dressings is clearly evident from the higher crude protein percentage every year when the 2+2, 4+2 and 6+2 treatments are compared with the 4, 6 and 8 cwt. per acre initial dressings respectively.

Conclusions

This experiment shows that over a period of three years, taking two cuts annually and grazing down in the autumn, an increase of approximately 50 per cent in yields of dry matter and crude protein was obtained through the application of 4 cwt. of sulphate of ammonia per acre either in single or split dressings. Further increases were obtained by using heavier dressings of nitrogen. The increase in total dry matter was linear up to 6 cwt. sulphate of ammonia per acre, and that of the total crude protein linear from the 2 to the 8 cwt. dressings. The responses for dressings above these levels were less.

Although only small differences were obtained between the single and the split dressings for the total dry matter and crude protein yields of the two cuts, it is considered an advantage to split the dressings in order to obtain a higher percentage of crude protein in the dry matter from the second cut. Thus the crude protein percentages of the two cuts are brought closer to each other whilst, at the same time, that of the first cut is still at a satisfactorily high level.

The yields of dry matter and crude protein have been well maintained in the third year of the experiment despite the changes in the botanical composition of the swards. It remains to be seen whether this production can be maintained with these treatments for a further year.

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